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UPGRADING OF THE MAFRAQ WASTEWATER TREATMENT PLANT FINAL CONCEPTUAL DESIGN REPORT

سلطة المياه

WATER AUTHORITY

December 2005

This publication was produced for review by the United States Agency for International Development and the Water Authority of Jordan. It was prepared by Stearns & Wheler in cooperation with MWHAJ for ECODIT under subcontract with IRG.

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Environmental Engineers and Scientists

IRG

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FINAL CONCEPTUAL DESIGN REPORT

FUNDED UNDER THE WASTEWATER TREATMENT FACILITIES FOR SMALL COMMUNITIES IN JORDAN PROJECT

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Upgrading of the Mafraq Wastewater Treatment Plant

Conceptual Design
Final Report

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List of Acronyms

The following are acronyms and their meanings that are used in this document:

AADF	Annual Average Daily Flow
AIPS	Advanced Integrated Pond System
AL	Aerated Lagoons
ASB	Aerated Stabilization Basins
BOD	Biochemical Oxygen Demand
C	Centigrade
CBOD	Carbonaceous Biochemical Oxygen Demand
CCP	Composite Correction Program
COD	Chemical Oxygen Demand
CPE	Comprehensive Performance Evaluation
CW	Constructed Wetlands
DB	Dosing Basin also Distribution Box
EPA	Environmental Protection Agency
ED	Existing Disinfection
FRP	Fiberglass Reinforced Plastic
Ha	Hectare (10,000 square meters)
HDPE	High Density Polyethylene
hp	Horsepower
HRT	Hydraulic Retention Time
Hz	Hertz
I/I	Infiltration/Inflow
ISF	Intermittent Sand Filters
Kg	Kilogram
kVa	Kilovolts
LDPE	Low Density Polyethylene
m	Meter
m^3	Cubic Meters
MCC	Motor Control Center

mg/L	Milligram per Liter
min	Minute
mm	Millimeter
MMADF	Maximum Month Average Daily Flow
MWI	Ministry of Water and Irrigation
NBOD	Nitrogenous Biochemical Oxygen Demand
NTU	Nephlometric Turbidity Unit
O&M	Operation and Maintenance
PDN	Pre-Denitrification Basin
RPM	Revolutions per Minute
RSF	Recirculating Sand Filters
RSS	Royal Scientific Society
Sec	Second
SBOD	Soluble Biological Oxygen Demand
SCBOD	Soluble Carbonaceous Biochemical Oxygen Demand
SDB	Sludge Drying Bed
SDT	Settling, Digestion, Thickening Tanks
SL	Sludge Lagoon
SRS	Septage Receiving Station
SSL	Sludge Storage/Stabilization Lagoon
TDH	Total Dynamic Head
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TSS	Total Suspended Salts
USAID	United States Agency for International Development
UV	Ultraviolet
VSS	Volatile Suspended Solids
WAJ	Water Authority of Jordan
WSP	Waste Stabilization Pond
WWTP	Wastewater Treatment Plant

Section 1 Introduction

1.1 Background

The Water Authority of Jordan (WAJ) is cooperating with the United States Agency for International Development (USAID) to study and upgrade the existing wastewater treatment plant (WWTP) for the Town of Mafraq in Northern Jordan. USAID added the assessment for upgrading this plant through a modification to an existing contract (Contract No. EPP-I-800-03-00013-00, Task Order No. 800) with IRG, under which ECODIT is leading the implementation of the Wastewater Treatment and Reuse for Small Communities Project (or the Small Communities Project). Under this task order modification, Stearns & Wheler provided the engineering services and completed an assessment of the upgrading of the Mafraq wastewater treatment plant. This is documented in a report titled "Assessment of the Upgrading of the Mafraq Wastewater Treatment Plant", July 2005. The Water Authority of Jordan and USAID approved the proposed upgrading philosophy in August 2005, and authorized the conceptual design of the Mafraq wastewater treatment facility.

1.2 Project Scope

The conceptual design activities presented in this report include design basis, preliminary sizing, and preliminary drawings/layout of the new treatment units and equipment included in the Assessment Report findings. The conceptual design took into account the existing Jordanian design standards and construction practices.

The conceptual design report covers the technical aspects of the upgraded, added or modified treatment units. It summarizes the design basis, the description of the specific size and functions of each treatment unit, the wastewater treatment flow sheet, the hydraulic profile and the preliminary layout of the wastewater treatment facilities. Other members of the Small Communities Team will develop capital and O&M cost estimates for the recommended improvements.

1.3 Summary of Assessment Report

The Assessment Report concluded that the wastewater treatment facility, can be upgraded using a lower technology approach. The proposed treatment processes are simple to operate and maintain and can produce a high quality effluent that meets the proposed effluent criteria (JS 893 2002, Discharge to Wadi) [1], and enhances water reuse opportunities. The existing facility is depicted in Figure 1, found in the Appendix.
The Assessment Report recommended the following:

1. Reconstruct the screening facility
2. Replace the anaerobic ponds with above-ground sedimentation/thickening tanks for rapid solids removal
3. Provide a septage receiving facility
4. Build one new aerated stabilization pond (completely mixed) and upgrade the existing anaerobic ponds (Figure 1, Appendix) (A-11 and A-21) and the facultative lagoons (F-11, F-12, F-21, and F-22) after the upgraded plant is placed in operation and flow can be diverted around these existing structures.
5. Convert two maturation ponds (M-11 and M-21) into dosing basins for the recirculating sand filters.
6. Clean and restore the chlorine contact tanks.
7. Build ten recirculating sand filters and recycle the nitrified effluent (recycle ratios varying from 1:1 to 5:1) to a pre-denitrification basins.
8. Build two pre-denitrification basins, located upfront of the aerated stabilization basins. Sixty percent of the volume of the pre-denitrification basins will be filled with plastic media, maintained in suspension by one mechanical mixer per tank. The media promote good contact between recycled nitrates and denitrifying bacteria resident on the media.
9. Build ten reed beds, used to polish the treated effluent.

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[1] JISM Technical Regulations Water – Reclaimed Domestic Wastewater JS 893/2002

10. Build sludge processing facilities including:
    - Sludge storage/stabilization lagoon.
    - Sludge drying beds.
    - Windrow composting pads.
11. Reconstruct the administration/maintenance building.
12. Consider in the detailed design phase of the project the following aspects:
    - High flow storage ponds.
    - Instrumentation/control systems.
    - Emergency generator.
    - Other essential items for flexible operation of the upgraded plant.

Typical representations of these structures may be found in the Appendix.

1.4 Organization of the Report

This report is organized into three sections and includes an Appendix containing several figures.

Section 1 is the Introduction. It sets the project background, discusses the project scope and summarizes the Assessment Report that preceded this Conceptual Design Report.

In Section 2, we discuss the project setting, including its physical setting and the design basis for the upgraded, expanded plant.

Section 3 provides a detailed process description for the upgraded expanded plant, including a discussion of equipment redundancy and reliability.

Appendix 1 to this report contains 10 figures which illustrate concepts discussed in the text. Appendix 2 includes the conceptual design calculations.

Section 2 Project Description

2.1 Location

Mafraq is a City located approximately 60 km northeast of Amman with a population of approximately 48,000. A gravity collection system conveys wastewater approximately 8 km to the wastewater treatment plant (WWTP) north of Mafraq. The pipeline grades are relatively flat and the wastewater is typically septic when it reaches the site. The site is approximately 600 m above sea level.

2.2 Climate

Summers in the project area are hot and dry, while winters are cool and rainy. Rainfall is variable and generally occurs during a three-month winter period. Air temperatures during the summer regularly exceed 35 degrees C, and occasionally 40 degrees C. Average daily winter temperature can fall below 5 degree C. The expected wastewater temperature range is between 17 and 27 degrees C.

2.3 Site Soil and Geology

The site's soil and geology have been described in previous studies (2001 Study). This report describes the site stratigraphy "as a limited thickness of soft chalky marl over a massive, semi-crystalline limestone, dolomite and dolomatic limestone, which may extend down to a maximum thickness of 110 m". Soil exploration of the site was undertaken in 2001 and 2002, and is documented in a "Geotechnical Investigation Report – Mafraq WWTP Project" dated July 2003 by the National Center for Engineering Studies under subcontract to CH2M Hill.

The main conclusions of the soil exploration study are that shallow rock formations are present in the western part of the site, where shallow treatment units could be located without major excavation work (sludge drying beds for example). The presence of surface rock formations also prompted a relocation of the water reuse storage basin from that included in the Assessment Report.

2.4 Surface Water Hydrology

The site slopes from east to west at about 2 percent toward the Wadi. At the western edge of the site, delineated by the wastewater treatment site property line fence, there is a steep drop-off of approximately 10 meters into the Wadi. There are currently two ditches draining runoff around the treatment ponds toward the Wadi. During the detailed engineering phase of the upgrade, new drainage and storm water collection system must be developed.

2.5 Existing Land Use

Currently the land use on the 37 hectares WWTP consists of the following areas:

- Approximately 9 ha of Waste Stabilization Ponds (WSP) and Reuse Pumping Station;
- Approximately 2 ha of maintenance roads, administration building, and areas along the south perimeter fence irrigated with potable water;
- Approximately 2 ha on the west side of the site that are not irrigated and have sparse vegetation;
- Approximately 24 ha of reuse area irrigated with treated effluent.

The Water Authority of Jordan (WAJ) has purchased additional tracts of land, intended to be leased to local farmers willing to reuse the treated effluent from the upgraded plant. Some of that area will be used for the 90,000 m^3 water reuse pond.

2.6 Existing Facilities

The existing Mafraq wastewater treatment plant (WWTP) was constructed in 1988 and includes headworks, two sets of waste stabilization ponds (WSP) in series, and one chlorine contact tank. The WSPs are approximately 1.5 m deep and are unlined. The final effluent is reused by the nearby farmers.

During the upgrade assessment of the facility it was found that the majority of the existing ponds could be reused and included as part of the rehabilitated treatment facility.

2.7 Site Utilities

The WWTP at the site is in operation and onsite utilities include electrical power and potable water. The existing electrical feed to the site is 1500 kVa.

2.8 Design Basis

As recommended in the Assessment Report, the wastewater treatment plant was designed for the following population size and wastewater treatment flow rates.

Table 2.8-1

Population and Influent Flows

Year	Population Estimate	Percent Sewered	Sewered Population	Water Consumption (units)	% Captured Flow	Average Flow Rate (m^3/day)	Maximum Month Flow Rate (m^3/day)
2005	46,883	55	25,786	104	80	2,145	3,000
2015	63,285	65	41,135	136	80	4,476	6,270
2025	82,076	75	61,557	133	80	6,550	9,170

Notes:

1. Population and average wastewater flow rates were estimated in a previous study.
2. Ratio of maximum month wastewater flow to average daily influent was estimated in a previous study at 1.4
3. Ratio of peak hour influent flow rate to average daily influent flow, as observed during the same study, is 2.

The design influent wastewater parameters for the upgraded Mafraq WWTP are shown in Table 2.8-2.

Table 2.8-2

Influent Sewage Characteristics and Design Loads

Year	Sewered Population	BOD_5		TSS		TN		TP	
		mg/L	kg/d	mg/L	kg/d	mg/L	kg/d	mg/L	kg/d
2005	25,786	925	1,985	925	1,985	156	335	54	116
2015	41,135	708	3,167	708	3,167	119	535	41	185
2025	61,557	724	4,740	724	4,740	122	800	42	277

Table 2.8-3 provides a summary of the effluent design criteria used for the conceptual design of the proposed treatment facility. The effluent criteria are based on the Jordanian Standard JS 893 2002 for discharge to Wadis.

Table 2.8-3

Effluent Design Criteria

Parameter	Units	Effluent Requirements
BOD	mg/L	60 (filtered)
COD	mg/L	150
TN	mg/L	70
NO_3-N	mg/L	10
TP	mg/L	--
DO	mg/L	≥ 1.0
Turbidity	NTU	--
pH	-	6-9
E. Coli	colonies/100 mL	1,000
Intestinal Helminthes Eggs	eggs/L	≤ 1.0

2.9 Treatment Processes

The upgraded wastewater treatment plant serving the Town of Mafraq will include the following unit processes:

- Septage Receiving Station
- Screening Facility
- Wet Weather Storage Lagoon
- Influent Pumping Station
- Settling/Thickening Tanks
- Pre-dentitrification Basins
- Aerated Stabilization Basins
- Facultative Lagoons
- Dosing Basins
- Recirculating Sand Filters
- Nitrate Recycle Pumping Station
- Reed Beds
- Maturation Ponds
- Chlorine Disinfection
- Sludge Storage/Stabilization
- Sludge Drying Beds
- Windrow Composting
- Water Reuse Storage Pond

Space has been reserved for a water reuse storage pond, and a water reuse pumping station. The choice of the pond size (90,000 m3) was recommended in an engineering assessment performed in 2001 and approved by WAJ and USAID.

Figure 5 in the Appendix shows the schematic flow diagram of the upgraded WWTP.

2.10 Power Requirements

The onsite transformer should provide 3-phase, 400 V, 50 Hz electrical power. All motors over 4 hp should be compatible with this equipment. Smaller motors should be 230/400 volts, 50 Hz.

2.11 Design Drawings

A set of conceptual engineering drawings has been prepared for the design for the Mafraq WWTP. The conceptual design drawings include the following:

- Figure 1 Existing Facilities
- Figure 2 Topographic site plan with soil boring location
- Figure 3 Process Flow Diagram
- Figure 4 Mass Balance Diagram
- Figure 5 Proposed Wastewater Treatment Facilities (site plan)
- Figure 6 Future Expansion(Beyond 2025)
- Figure 7 Hydraulic Profile

The drawings are presented in the Appendix. Figures 8 through 10 of the Appendix are typical representations of other proposed unit processes, but they have not been sized nor drawn specifically for this project.

2.12 Administration Building

The Administration Building was designed with an overall floor area of 300 m^2. It should include the following main components:

- Supervisor's office
- Staff office
- Laboratory
- Spare parts storage
- Lockers, toilets, showers
- Service/maintenance area
- Motor Control Room
- Kitchen and break room
- Entrance Lobby

The detailed design of the administration building should comply with all existing codes and regulations currently established in Jordan.

Section 3 Process Description

The recommended wastewater treatment processes discussed herein will provide a cost-effective solution for upgrading the existing wastewater treatment facility to comply with Jordanian Standard JS 893 2002. The technologies selected are proven wastewater treatment processes that are reliable and require minimal operator intervention. The liquid process treatment train will consist of septage receiving station, influent screening, wet weather storage lagoon, influent pumps, sedimentation/thickening tanks, aerated/facultative/maturation lagoons, recirculating sand filters, and constructed wetlands. Treated effluent will be stored in a treated effluent storage basin. The solids treatment train will include an aerated sludge holding lagoon for biological stabilization of the solids, sludge drying beds for dewatering, and composting facility. Dewatered solids from the sludge drying beds can either be trucked to a landfill for final disposal or composted for beneficial use on agricultural land. Figure 5 in the Appendix provides a site plan with the proposed improvements.

3.1 Septage Receiving Station

A septage receiving station should be provided at the Mafraq WWTP in the vicinity of the new screening facility. The purpose of the septage receiving area is to facilitate the acceptance of wastes from the off-site septic tanks and other domestic sources that are delivered to the treatment plant by tanker trucks.

An unloading area will be provided for the trucks to unload without impeding other WWTP traffic. The unloading area should be constructed to contain septage, and allow washdown water and spillage to drain into the wetwell.

The septage screening area will be a reinforced concrete slab designed for a full tanker, surrounded on two or three sides by a curb, with safe access from the open side. Septage will drain through a screen and pipe into a septage wetwell.

The septage wetwell should be rectangular in shape and have a minimum volume of 70 m^3. It should be fitted with two wastewater pumps operating on a duty/standby basis. The pumps will transfer the screened septage to the influent raw sewage channel upstream of the screens. The septage receiving station should consist of the following components:

- Reinforced concrete pad for septage receiving and truck unloading
- Septage screen
- Septage wetwell
- Septage transfer pumping station and accessories.

Table 3.1-1

Septage Receiving Station

Description	Value
Operating volume of the septage station	70 m^3
Number of transfer pumps	2
Discharge piping	100 mm minimum
Largest solids passing	7.5 mm
Minimum pumping capacity	300 L/min

3.2 Screening Facility

Flow will enter the screening facility via a new channel. The existing screening channels will be closed and bypassed after the plant is upgraded. Downstream of this common channel, individual channels should be provided for the influent screens. Inlet and outlet slide gates should be provided for isolation of each channel. Aluminum handrailing around the outside of the structure will be provided. The unit should also include a bypass channel with a manually cleaned screen. This screen should be designed to allow overflow at peak flow conditions if the screen becomes blocked.

Screenings removed from the wastewater are to be discharged into an open dumpster located below of the mechanical screen.

The emergency overflow in the Bypass Chamber will be set at an elevation to divert flows which exceed 13,300 m^3/day to a Wet Weather Storage Lagoon (WWSL). When the flow rate to the plant exceeds 13,300 m^3/day the water level will rise in the Bypass Chamber. When the water level reaches a pre-determined depth in the Bypass Chamber, it will flow over a weir and then by gravity to the Wet Weather Storage Basin. Once flow subsides and the water level in the Bypass Chamber decreases to a level below that in the Storage Basin, a slide gate will be opened on a gravity line to enable water to flow from the Basin back to the Bypass Chamber and on to subsequent unit processes.

3.2.1 Mechanically Cleaned Screen

The mechanical screen recommended for the Mafraq WWTP will use shaftless spiral technology to perform screening, solids conveying, and dewatering in one step. This type of screen will minimize odors and the volume of screenings requiring final disposal.

As liquid flows through the screening basket, solids are trapped by the screen bars that form the circular basket. When the liquid reaches to a predetermined level, the rake begins to rotate to clean the screen bars. The rake’s teeth pass between the bars of the screen to remove the screened material. When the rake reaches the top of the screen, the captured material drops into a central screw conveyor.

Table 3.2-1

Mechanically-Cleaned Screen Requirements

Item	Description
Maximum screen opening size, mm	6 mm
Maximum design flow	50% peak flow
Maximum headloss when 50% blocked, mm	300 mm
Minimum freeboard at full bypass, mm	300 mm
Average approach velocity, m/s	0.6
Number of Units	2

3.2.2 Manual Bar Screen

A manually-cleaned screen is provided in the bypass channel. The manual bar screen should have 25 mm openings and be designed for the peak flow. All wetted parts should be Type 316 stainless steel. The screen will be of robust construction and structurally able to sustain a water head equivalent to the height of the channel (i.e., as if blocked) without damage. The screen should be designed for manual cleaning with a minimum of effort and include all equipment necessary for removal of screenings, (rakes, wheeled dumpsters, etc.).

3.3 Wet Weather Storage Lagoon

A 13,000 m^3 wet weather storage lagoon (WWSL) is required to store wet weather flows exceeding 13,300 m^3 of influent wastewater flow. The WWSL will be an earthen basin with a minimum 1 mm, HDPE or LLDPE membrane.

Features should be included to prevent erosion and undermining of the lagoon embankment by any overflows. Yard piping and valves are part of the detailed design, allowing diverted flows to be returned by gravity to the head of the plant for further treatment.

3.4 Influent Pumping Station

Following influent screening, the wastewater will be directed to an influent pumping station. The influent pump station will include four pumps (3 duty and 1 standby). Each pump will be rated for a capacity of 3,030 L/min. All pumps are constant speed. Pumps are activated based on water levels in the pumping pit. The influent pumps will lift the screened wastewater into the first distribution box, DB No. 1, splitting the screened flow between the two settling/thickening tanks. The influent pumping station lifts the wastewater and ensures gravity flow between all subsequent treatment processes.

Table 3.4-1

Design Flows

	Units	Average flows	Maximum Monthly flows	Peak Daily flows
2005	m^3/day	2,145	3,000	4,290
2015	m^3/day	4,476	6,270	8,970
2025	m^3/day	6,650	9,170	13,110

Table 3.4-2

Influent Pumping Station

Item	Value
Influent Pumping Station Firm Capacity, L/min	9,240 L/min
Minimum Flow, L/min	3,030 L/min
Number of pumps	4 (3 duty + 1 standby)
Pump Type	Submersible, recessed impeller
Capacity each, L/min	3,030 L/min
Motor size, kW	20
Total dynamic head, m	20
Maximum sphere passage, mm	100 mm
Suction/discharge size, mm	100 mm

3.5 Flow Distribution

The purpose of the flow distribution box is to split the flow evenly between the individual process units of each treatment train.

There are five flow distribution boxes in the plant. The purpose of Flow Distribution Box No.1 is to divide the screened influent flow evenly between the two settling/thickening tanks (SDT). The normal distribution of flow will be 50 percent of the screened influent wastewater flow to each SDT. Both SDTs have the same dimensions. The equal distribution between both SDTs is accomplished in the flow distribution box by providing weirs of equal length set at equal height. If the operators desire to shut down one of the settling/digestion tanks for maintenance, a stop plate can be placed in front of the weir to stop flow into that SDT. The flow distribution box also has a slide gate which will allow part of the flow to be bypassed around the SDT and directly into Flow Distribution Box

No. 2, feeding the Pre-Denitrification Basins (PDN). This feature can be used to increase the amount of COD entering the PDN for periods when the denitrification process is carbon limited.

The purpose of Flow Distribution Box No. 2 is to divide the combined, settled influent and nitrate recycle flows evenly between the two PDN basins. There are several weirs, each 0.6 m long, along one side of the distribution box which overflow into the PDN influent channel and then into the PDN. There are two weirs, each 0.5 m long along the other side of the distribution box which overflows into a drop box that connects to the downstream units (Facultative Lagoons and Reed Beds). By using stop plates to cover some of these weirs, the operators can achieve a 1:1, 2:1, 3:1, 4:1, or 5: 1 nitrate recycle rate, and achieve denitrification in the other treatment units as well.

The purpose of Flow Distribution Box No. 3 is to divide the PDN effluent flow evenly between the two parallel sets of Aerated Stabilization Basins (ASBs). The normal distribution of flow will be 50 percent of the denitrified flow to each ASB. Both ASBs have the same dimensions. The equal distribution between both ASBs is accomplished in the flow distribution box by providing weirs of equal length set at equal height. If the operators desire to shut down one of the basins for maintenance, a stop plate can be placed in front of the weir to stop flow.

The purpose of Flow Distribution Box No. 4 is to dose the flow adequately onto the Recirculating Sand Filters. The suggested operational mode is described in more detail under the RSF operational procedures.

The purpose of Flow Distribution Box No.5 is to distribute the RSF effluent between the pre-denitrification basins, the facultative lagoons, and the reed beds. The equal distribution between the reed bed cells is accomplished in the flow distribution box by providing weirs of equal length set at equal height. Stop plates are provided for cell isolation for cleaning purposes.

3.6 Sedimentation/Thickening Tanks

The purpose of the sedimentation/thickening tanks is to remove the largest possible fraction of suspended solids entering the upgraded facility. This process is carried out by providing settling zones equipped with lamella separators. These are inclined, parallel plates fitted in modules in the tank. The velocity of water through the lamella is restricted in order to create a laminar flow thus improving the separation process. The thickening function is accomplished in the conically shaped bottom portion of each tank.

The sedimentation/thickening tanks are painted carbon steel tanks with conical bottoms equipped with plate settlers to maximize liquid/solids removal efficiency. The units have no moving parts. The conical bottoms produce a high underflow solids concentration, thereby minimizing the sludge volume requiring treatment. The underflow pipe will be accessible and equipped with a manual isolation valve. Solids will flow by gravity from the units to a sludge pumping station. From the pumping station they will be conveyed to the sludge storage/stabilization lagoon.

Influent enters the inclined plate settler area via a conduit sized to provide a velocity lower than 0.122 m/sec at design flow. A stilling/distribution chamber follows to dissipate the entrance energy and equalize flow to the side of the plates. Influent is then directed into the side-feed conduits, enters the sides of the plates, and rises upwardly to overflow weirs. The side-feed slots between the plates should be sized to ensure sub-laminar flow conditions so that floc shearing does not occur. The sediment then flows by gravity to the sludge storage hopper.

Painting of all interior parts should include the following: surface preparation (sandblast and surface profile of 2 mm minimum), prime coat (4 - 6 mm), finish coat (4 – 6 mm). Stainless steel, reinforced fiberglass, and galvanized components shall not be painted.
Table 3.6-1 summarizes the main design parameters of the sedimentation/thickening tanks.

Table 3.6-1

Sedimentation/Thickening Tanks

Item	Value
Design flow rate	6,550 m^3/day
Maximum flow rate	150 L/sec
Number of units	2
Dimensions (if round)	4 m diameter x 7.16 m height
Maximum hydraulic loading rate	1.22 m/hr
Plate size	1.22 m x 3.05 m x 2.3 mm
Plate material	FRP
Effective settling area/unit	221.74 m^2
Number of plates/unit	130 (in 2 rows of 65 plates each
Perpendicular plate spacing	76.2 mm x 45 degree V-notch weir plates FRP*
Effluent launders	Adjustable 76.2 mm x 45
Access platform	91.4 cm wide access with 1 access ladder
Expected influent TSS	725 mg/L – 1,500 mg/L
Design efficiency	80%
Phosphorus removal possibility	By chemical addition

*FRP – Fiberglass Reinforced Plastic.

Bypass of the any one of the sedimentation/thickening tanks is possible by using the valves (please consult Figure 3) ahead and after the units.

3.7 Pre-Denitrification Basins

The purpose of the Pre-Denitrification basins is to remove the oxidized nitrogen (nitrate and nitrite) by the biological process of denitrification. This process is carried out by the heterotrotrophic bacteria operating in an anoxic environment. The bacteria require a carbon source to carry out the denitrification process. The carbon source in this application is the COD present in the settling/thickening tank effluent. Additional COD can be supplied by directly bypassing a portion of the influent wastewater from Flow Distribution Box No. 1 around the sedimentation/thickening basin. The effluent from the sedimentation/thickening contains most of the nitrogen present in the form of TKN. Therefore, a portion of the effluent from the RSF's (in which the nitrification process has converted ammonia into oxidized nitrogen) must be recycled back to the denitrification basin (the facultative lagoons have also contributed to the nitrification process). This is accomplished by the recycling pumping station, which pumps nitrates from the RSF into the Nitrate Recycle Flow Distribution Box (Flow Distribution Box No. 5). To maintain constant and healthy denitrifying biomass, fixed type media is inserted into the denitrification basin. The media contains high amounts of denitrifiers, and by constant mixing, provides good contact between the denitrifiers and the recycled nitrates. Sludge pumps can be used to withdraw the excess biomass from the denitrification basins and pump it onto sludge drying beds for dewatering. The main characteristics are presented in Table 3.7-1

Table 3.7-1

Pre-Denitrification Basins

Item	Value
Number of units	2
Mode of operation	In parallel
Material	Bolted Steel Tanks
Diameter	25 m
Surface area	1,000 m^2
Water Depth	5 m
Volume	5,000 m^3
Volume Occupied by the Media	60%
Nominal HRT Contact Time	36.6 hrs at design flow
Number of Mixers	1 per tank
Motor of each mixer	40 hp

The denitrified effluent is discharged into the next biological step: the aerated stabilization basins, where the remaining ammonia nitrogen is converted to nitrates.

3.8 Aerated Stabilization Basins

The purpose of the Aerated Stabilization Basins (ASB) is to provide an environment leading to significant degradation of the organic matter (BOD), as well as some nitrification.

The ASBs in Mafraq will have the following components.

- ASB 11: is a completely mixed earthen basin, build in parallel with the existing anaerobic waste stabilization pond cells numbered A-1 and A-2.
- ASB 21: Cells A-1 and A-2 will be merged together after the completion and start-up of the upgraded WWTP. The existing dividing wall between A-1 and A-2 will be demolished. The new basin (ASB 21, which is the completely mixed cell of treatment train 2) will have larger footprint at the bottom elevation, a prerequisite for an efficient upgrading to a completely mixed aerated lagoon.
- ASB 12: Cells F-12 and F-22 will be merged together after the completion and start-up of the upgraded WWTP. The existing dividing wall between F-12 and F-22 will be demolished. The new basin (ASB 12, which is the partially mixed cell of treatment train 1) will have larger footprint at the bottom elevation, a prerequisite for an efficient upgrading to an aerated lagoon.
- ASB 22: Cells F-11 and F-21 will be merged together after the completion and start-up of the upgraded WWTP. The existing dividing wall between F-11 and F-21 will be demolished. The new basin (ASB 22, which is the partially mixed cell of treatment train 2) will have larger footprint at the bottom elevation, a prerequisite for an efficient upgrading to an aerated lagoon.
- FL 13: Existing facultative pond F 13 will be used as "polishing cell" for the effluent from the ASBs of train 1 (ASB 11 and ASB 21). Solids overflowing the weir from ASB 12 will settle at the bottom of this lagoon and undergo anaerobic decomposition with time. Periodic removal of the settled solids will be required. The probable frequency might be every 5 to 7 years. Solids removed from this cell will be pumped onto sludge beds for drying and disposal.
- FL 23: Existing facultative pond F 23 will be used as "polishing cell" for the effluent from the ASBs of train 2 (ASB 12 and ASB 22). Solids overflowing the weir from ASB 12 will settle at the bottom of this lagoon and undergo anaerobic decomposition with time. Periodic removal of the settled solids will be required. The probable frequency might be every 5 to 7 years. Solids removed from this cell will be pumped onto sludge beds for drying and disposal.

In Aerated Stabilization Basins (sometimes referred as aerated lagoons, or aerated ponds), oxygen will be supplied mainly through mechanical aeration. The ASBs typically are classified by the amount of mixing provided. A partial mix system (ASB 12 and ASB 22) provides only enough aeration to satisfy the oxygen requirements of the system and does not provide energy to keep solids in suspension. A complete mix system (ASB 11 and ASB 21) is similar to the activated sludge treatment process, except that it does not include recycling of cellular material, resulting in lower mixed liquor suspended solids concentrations. Some solids in the partial mix basins are going to be kept in suspension to contribute to overall treatment. This allows for anaerobic fermentation of the settled sludges.

The detailed design should provide piping for interconnection between all basins, allowing parallel or serial operations, as well as bypassing of each cell of this unit process.

Aeration requirements are described in Table 3.8-1.

Table 3.8-1

Aerated Stabilization Basins Aeration

Description	Value
ASB 11 & ASB 21	4 x 35 hp floating aerators in each cell
ASB 12 & ASB 22	2 x 35 hp floating aerators in each cell
Floating aerators	35 hp, 50 HZ, Stainless steel, accessories
Energy rating each aerator	2 kg O_2/Kw-hr
Total aeration requirements	6,500 kg O_2/day (BOD + nitrification)
Aeration capacity 1 x 25 kW	900 kg O_2
Total capacity 12 x 35 hp	10,000 kg O_2
ASB 11 & ASB 21	8 x 35 hp (7,200 kg O_2)
ASB 12 & ASB 22	4 x 35 hp (3,600 kg O_2)

3.9 Facultative Lagoons

Two existing facultative lagoons (F 13 and F 23) will be kept operational and integrated into the upgraded treatment plant (redesignated FL-13 and FL-23). The purpose of these basins is to remove the biological solids that have not settled in the last cell of the aerated stabilization basins and to provide conditions allowing nitrification to proceed. The process is carried out by the nitrifying microbial population established in an environment with low carbon content (the majority of the organics will be degraded/removed by the previous treatment units). Table 3.9-1 presents the main characteristics of the facultative basins (existing structures).

Table 3.9-1

Facultative Basins

Description	Value
Number of basins	2, operated in parallel
Dimensions	93 m x 37 m x 1.75 m water depth
Surface area each	3,552 m^2
Total surface area	7,000 m^2
Volume each basin	3,814 m^3
Total volume	7,628 m^3
Nominal HRT	27 HRS

3.10 Recirculating Sand Filters

The primary purpose of the Recirculating Sand Filters (RSF) is to accomplish nitrification. Additional reduction of BOD and some degree of denitrification will also take place in the RSFs. The denitrification is possible in portions of the RSF which do not receive adequate oxygen. The primary source of oxygen in the RSFs is diffusion of oxygen into the upper layers of the sand from the air. This effect is enhanced by frequent "tilling" of the sand on the surface, as well as by aeration tubes. The tilling process involves turning the top few centimeters of sand to expose the bacteria growing on the sand grains to the surface air. The tilling process also breaks up the hardpan of solids and algae which tends to build up on the RSF surface over time. Some oxygen will also enter the bottom of the RSF through the open under drains. Ten RSFs are proposed for the Year 2025 design flow. Two RSFs are dosed at a time in the Year 2025 design. Each RSF is dosed once every five dosing periods. There are three dosing periods each day. In each dosing period, the slide gate at the end of the dosing basins is opened, sending a rush of stored wastewater onto the surface of two of the RSFs. The flow of wastewater onto the RSF surface is faster than the liquid can percolate through the sand, so the liquid ponds on top of the sand surface. The ponding results in an even depth of wastewater over the entire RSF surface, which in turn, ensures an even distribution of flow across all parts of the RSF. Over the course of several hours, the ponded wastewater percolates through the sand particles where attached bacteria carry out the nitrification process. The close packing of the sand grains also filters out the solids and some bacteria from the liquid.

Table 3.10-1 summarizes the main characteristics of the Recirculating Sand Filters.

Table 3.10-1

Recirculating Sand Filters Characteristics

Description	Value
Number of units	10 (or more if the surface area of each RSF is reduced)
Surface area each	5,000 m^2
Total surface area	50,000 m^2
Liner material	HDPE Geomembrane
Sand depth	0.6 m
Gravel depth	0.4 m
Dosing volume	1,500 m^3
Liquid head each dose	300 mm
Design recycle ratios	1:1 to 5:1

3.11 Nitrate Recycle Pumping Station

The effluent from the RSFs drains into a Nitrate Recycle Pumping Station (NRPS). The maximum water level in this pumping station must be kept below the bottom of the RSFs to allow the RSFs to drain completely. Due to the depth below grade, vertical turbine type pumps are recommended. The description provided in Table 3.11-1 presents the characteristics of these pumps. These pumps return a portion of the RSF effluent back to the front end of the pre-denitrification basins, and other front end unit processes. Such a multiple-points recirculation strategy gives additional flexibility to the operating staff to:

- Control odors
- Provide additional denitrification in other treatment units
- Provides a source of non-potable water for non-contact secondary needs

Table 3.11-2 shows flows to be pumped by the NRPS for various recycle rates over the 20-year design period.

The NRPS returns the RSF effluent back to the PDN unit to serve as a source of nitrates for the denitrification process.

The wet well of this pumping station has a large volume so that it can act as a flow equalization point. Even though liquid exits the RSFs at an inconsistent rate (due to the periodic loading method), the RSF's effluent flow will be equalized in the RPS and (when the stop plates are properly adjusted) the pump should operate at a constant rate throughout the 24 hour period.

Table 3.11-1

Nitrate Recycle Pumping Station Characteristics

Item	Value
Pumping Station Capacity	22,742 L/min
Number of pumps	4 (3 duty + 1 standby)
Pump Type	Vertical turbine type pumps
Capacity each, L/min	7,580 L/min
Motor size, hp	55
Total dynamic head, m	15
Maximum sphere passage, mm	254 mm
Discharge size, mm	1,500 mm
Pump RPM	1,770

Table 3.11-2

NRPS Recycle Flows Range

	Units	1:1	2:1	3:1	4:1	5:1
2005	m^3/day	2,145	4,290	6,435	8,580	10,725
2015	m^3/day	4,476	8,952	13,428	17,904	22,380
2025	m^3/day	6,550	13,100	19,650	26,600	32,750

3.12 Reed Beds

The primary purpose of the Reed Beds is to serve as tertiary treatment. The reed beds will also remove some nitrogen and other nutrients from the wastewater by uptake into the plants and by biological nutrient removal mechanisms. The nitrogen removal, however, could be partially offset during many parts of the year by the loss of water through the basins due to evapotranspiration which concentrates the nitrogen in the remaining water.

Because the main purpose of the upgraded Mafraq WWTP is to provide treated effluent for irrigation purposes, it is recommend that only half of the reed beds, be seeded initially. When the wastewater flow increases in the future, more reed beds should then be seeded.

Table 3.12-1

Reed Beds Characteristics

Item	Value
Number of units	10
Surface area each	3,000 m^2
Total surface area	30,000 m^2
Type of reed	Phragmites Communis
Liner material	HDPE Geomembrane
Material of construction	Earthen cells lined with HDPE
Sand depth	0.1 m
Gravel depth	0.8 m
Water depth	1 m
Type of System	Subsurface flow

3.13 Maturation Ponds

The purpose of the maturation ponds is to remove pathogens and provide additional clarification of the treated effluent. The Assessment Report proposed the direct reuse of the maturation ponds for pathogen control. In this conceptual design we are proposing to convert two of the four maturation ponds (M 11 and M 21) into RSF Flow Dosing Basins (DB-11 and DB-21), and use the remaining two (M 12 and M 22) as maturation ponds after the Reed Beds. We have tentatively selected a location for the two additional Maturation Ponds, but this location should be confirmed during final design. The relocation of the first two maturation ponds is necessary to accommodate the prevailing site conditions. As a matter of fact, it was discovered during the conceptual design that the rock formations found in the area of the RSF could be avoided by relocating the RSF and Reed Bed treatment units beside the existing waste stabilization ponds. Such relocation would require the dosing facilities be located higher in the hydraulic gradient.

Table 3.13-1 summarizes the main characteristics of the maturation ponds.

Table 3.13-1

Maturation Ponds Characteristics

Description	Value
Number of basins	4, two per rain
Dimensions	74 m x 37 m x 1.5 m water depth
Surface area each	2,800 m^2
Total surface area	7200 m^2
Volume each basin	2,470 m^3
Total volume	9880 m^3
Nominal HRT	35 Hours

3.14 Disinfection

Final effluent will be disinfected with liquid chlorine. The purpose of the chlorination system is to provide complete pathogen destruction by dosing the effluent with a specific amount of chlorine in a contact chamber. The contact chamber will provide 20 minutes hydraulic retention time at peak flows. The existing contact chamber could be integrated into the disinfection system by adding additional volume making structural repairs, and cleaning of the accumulated sludge. Based on the advanced degree of treatment achieved in the facility, projected chlorine dosing is between 1 and 5 mg/L. Expected residual chlorine would be approximately 0.5 mg/L.

The chlorine dosing requirements, including the residual chlorine should be reexamined during the detailed design to ensure reuse in irrigation is not detrimentally affected.

Table 3.14-1

Chlorination System Characteristics

Description	Value
Contact chamber volume	1,820 m^3
Water depth	1.8 m
Length/width ratio	50
Depth/width ratio	1
Chlorinator capacity	1,000 kg
Refilling frequency	1 per 15 days
HRT	15 at Peak Flow

3.15 Water Reuse Storage Pond

Treated Effluent from the reed beds will be conveyed, by gravity, to a water reuse storage pond. The pond will be used to temporarily store treated effluent prior to agricultural reuse. A geomembrane liner may be required, depending on soil conditions, to minimize seepage. Existing irrigation pumps may be used to convey the treated effluent to the agricultural fields. The 90,000 m^3 volume of the storage pond was selected in the 2001 Conceptual Design Report[2] and approved by the Water Authority of Jordan.

3.16 Sludge Storage/Stabilization Lagoon (SSL)

Solids removed in the sedimentation/thickening tanks on a daily basis will be transferred to the sludge storage/stabilization lagoon. The purpose of this treatment unit is threefold:

- Provide sludge storage/equalization to allow adequate time between sludge application onto the sludge drying beds
- Provide sludge stabilization by aerating the content of the basin for about 15 days
- Provide volume reduction by reducing the volatile content of the sludge

The average daily sludge production in 2025 will be approximately 3,400 kg per day. This mass of primary solids will be pumped from the sedimentation/thickening tanks into the SSL. Due to distance between the sedimentation/thickening tanks and the SSL, gravity flow of the sludge is not feasible. We recommend evaluation of an optional location for the sedimentation/thickening tanks during the detailed engineering phase of the project, in an effort to eliminate:

- The influent pumping station
- The sludge pumping from the bottom of the sedimentation/thickening tanks (SDT).

If such optional location of the SDT units (near the nitrate recycle pumping station) is not feasible, then sludge pumping would be required. The settled/thickened sludge will be

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[2] USAID, CH2MHILL, Mafraq WWTP and Reuse Application, Task 2 – WWTP Technology Assessment and Conceptual Design, June 2001

removed from the bottom of the SDT by a recessed impeller/screw type pumping station equipped with three pumps (2 duty and 1 standby). The capacity of each pump should be approximately 1,400 l/sec (sludge pumped 4 hr/day). Sludge removal would occur over 4 hr/day. The expected solids concentration will likely vary from 3 to 5 percent.

Aeration will be provided by a jet aeration type system or surface aeration, providing the flexibility to mix and aerate separately. Periods of mixing/aeration/decanting will allow for the separation of supernatant, yielding a higher consistency for dosing the drying beds. The aeration will prevent potential odor emission.

Table 3.16-1

Sludge Storage/Stabilization Lagoon (SSL) Design Loadings

Description	Value
Daily sludge production	3,400 kg/day
Initial volume	75 to 113 m^3
Final volume	50 to 74 m^3
Number of units	2
Size each	315 m^3
Total volume	630 m^3
Aerators	1 x 35hp per unit
Aeration system	Surface aerator or Jet aeration system

Biosolids will be produced in several other treatment units in the facility, including:

- Denitrification tank
- Aerated Stabilization Basins
- Facultative Lagoons
- Maturation ponds

We expect rather significant solids volume reduction in those units. It is anticipated that solids will need to be removed from those units once every 5 to 7 years.

Solids removed by pumping from the denitrification tanks, aerated stabilization basins, facultative lagoons and maturation ponds will then be applied to the sludge drying beds. Those solids are sufficiently stabilized, and do not require additional digestion in the sludge storage/stabilization tank.

3.17 Sludge Drying Beds

The purpose of the sludge drying beds is to dewater sludge produced by the plant. The liquid sludge is pumped from the Sludge Storage/Stabilization Lagoon by submersible pumps onto the surface of the sludge drying beds. The liquid portion of the sludge will partially evaporate into the atmosphere or drain through the sand in the drying beds into the under drain below. The under drain is piped back to the Nitrate Recycle Pumping Station. The dried sludge must be removed with a small loader and disposed of or used for composting and subsequent beneficial reuse.

The sludge drying beds will be constructed with insertion “honeycomb type cells” on which a lightweight front end loader can operate without compacting the sand and damaging the cell structure. The honeycomb structure protects the sand during sludge dredging and removal and will minimize sand losses.

Table 3.17-1

Sludge Drying Beds Characteristics

Parameter	Value
Number of units	35
Liner material	Concrete
Dimensions of each bed	12 m x 35 m
Total surface area	15,000 m^2
Average sludge flow	50 to 75 m^3/day
Feed solids concentration	3 to 5% dry solids
Average bed turnaround	40 to 50 days
Dried Solids Concentration	40 to 50 %

3.18 Windrow Composting

The purpose of the windrow composting cells is to provide an environment in which bacteria and fungi will decompose the remaining organic material in the dried sludge.

The recommended composting process is windrow composting. Dried solids, removed from the sludge drying beds, will be piled into one or two cells at a time. Bulking agents, such as wood chips, shredded agricultural residue, shredded solid waste, sawdust, finished compost, etc. are added to each batch (pile) of dry sludge. Each windrow of sludge and bulking agent should be approximately 0.9 to 1.8 m high and 1.8 to 4.9 m wide.

Under typical operating conditions, windrows are turned every second day throughout the composting period. To meet EPA’s pathogen reduction requirements, the windrows must be turned 5 times in a 15-day period, while maintaining 55 degrees Celsius temperature inside the pile.

Storage of a 15-day supply of bulking agent should be provided nearby. It is expected that approximately 15 m3 of dewatered sludge will be sent to the composting cells every 15 days.

3.19 Equipment Redundancy and Reliability

The upgraded wastewater treatment plant will have the ability to maintain effluent limits during periods when systems are offline for planned maintenance, or under atypical or adverse conditions, such as power outages, flooding, overloading, etc. For reliability purposes, Class I facilities are those “which discharge into navigable waters that could be permanently or unacceptably damaged by effluent which was degraded for only a few hours”. Mafraq effluent is discharged into the Yarmouk River, one of the main drinking water supplies for the area. Therefore, the proposed conceptual design took into consideration EPA's guidelines for Class I wastewater treatment facilities entitled: "Design Criteria for Mechanical, Electric, and Fluid System and Components Reliability".

In addition, the project will require a spare parts inventory due to the time it takes to get spare parts ordered and imported into Jordan.

3.19.1 Reliability

Processes associated with treatment of the main flow path (including ancillary systems required to maintain operation of a critical main stream process or system) are considered critical. Processes associated with solids handling and other ancillary functions are considered non-critical, as storage of 15 days is provided.

3.19.2 Redundancy

In all cases, processes are capable of hydraulically passing peak flows with the largest unit out of service (i.e. have sufficient hydraulic capacity to prevent overflows). Some on-line redundant components are provided as part of the conceptual design. In other cases, the second train will provide treatment redundancy. The pumping stations have been designed with at least one standby pump. In addition, spare parts for the key mechanical components should be included in the detailed design of the facility.

3.19.3 Maintainability

Sufficient redundancy in components and systems is included in the conceptual design to allow routine maintenance to occur without compromising normal treatment operations. The conceptual design took into account the maintenance requirements for the facility by providing two trains, and multiple, easily accessible treatment units. Back-up systems (pumps for example) will allow the plant staff to take individual components off-line, and service them without interruption of treatment.

3.19.4 Isolation

The design intent is that all treatment components can be readily isolated for maintenance and repair. Isolation should be provided by appropriate valves or stop plates, allowing cleaning or servicing channels, pipelines and/or basins, while maintaining flow to downstream processes.

3.19.5 Tank Draining

Some of the tanks, basins and ponds can be drained by gravity to a downstream process. Other basins and ponds will be drained by pumping, while others by decanting and pumping. Some basins will be constructed with internal sumps and facilities allowing the insertion of portable submersible pumps.

3.19.6 Access

The main mechanical components (pumps, screens and valves) will be readily accessible for routine maintenance and repairs. The submersible pumping stations will be equipped with dismounting systems (guide rails, manual hoists, and accessories). Sufficient space will be provided for component disassembly, removal, and repair.

3.19.7 Electric Power

The following features are required for the power source at the upgraded WWTP:

- Two separate independent sources of electric power will be provided. The first source will be the main electrical supply from the local grid, and the second a plant-based standby generator
- The two sources of electric power will be distributed to minimize failures
- The main grid source will have a separate transformer protected from common mode failures

- To support unit process reliability and redundancy requirements, the redundant electric power source must have capacity sufficient to operate all critical components and systems at peak flow conditions. This includes provisions for health and safety systems such as emergency lighting, minimum ventilation at the administration building, and monitoring/alarm of hazardous areas.

The internal power distribution system to each individual treatment component will be finalized during the detailed design of the facilities.

Due to the choice of treatment systems, very similar to natural purification processes, very little instrumentation and control system are required. In most cases manual controls will be provided, with operational status tracked, recorded and observed in the administration building electrical control room.

All alarms for critical components of the wastewater treatment system should be independent of the controls such that a single failure will not result in failure of both controls and alarms.

When on/off/auto control is provided at local control panels for critical components, loss of power at the panel must not preclude operation of the components in manual mode.

3.19.8 Other Support Systems (Heating, Ventilation, Air Conditioning, Plant Water System; Non-Potable Water System)

HVAC

All HVAC systems essential for safety, such as laboratory ventilation, as well as ventilation for all enclosed vessels and chemical storage rooms, will be treated as critical components or systems. Provisions should include adequate power and control redundancy as previously discussed such that downtime for service or component failure does not compromise safety. Examples include ventilation of the chlorine storage room and the WWTP laboratory room.

PLANT WATER AND AIR SYSTEMS

Similar provisions as those described above for HVAC will be applied to plant water, air, and other miscellaneous systems serving critical components. Such systems will include:

- Critical pump seal water
- Standby engine generator cooling system
- Fire protection water pumping system (if required)
- Instrument air systems

3.19.9 Flash-Flood Protection

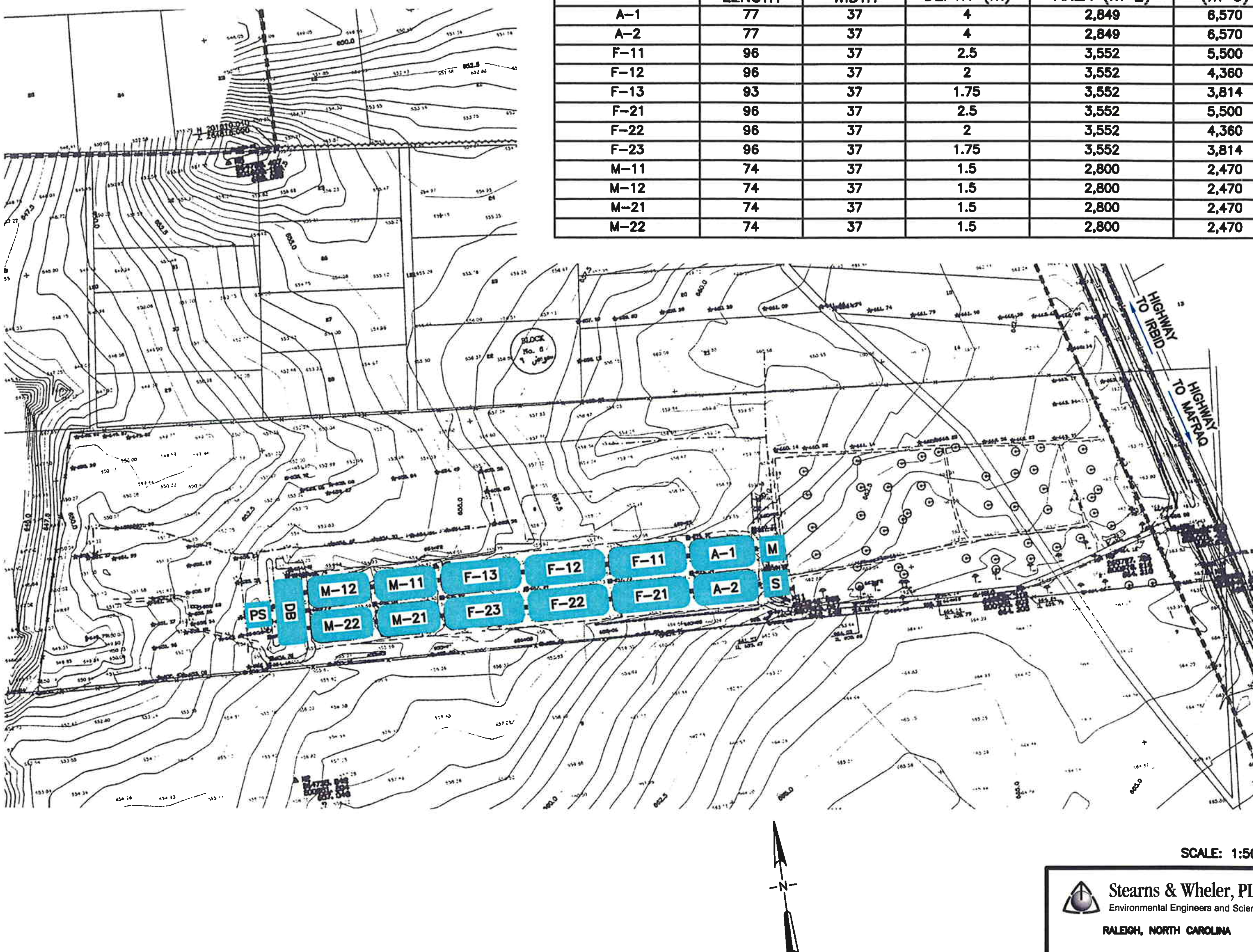
Flood protection provisions and criteria for flood event frequencies must be verified with the appropriate Jordanian agency. However, as a minimum, the detailed design must include provisions to assure that the WWTP remains fully operational (i.e. maintains all critical functions necessary for permit compliance or other defined goals) during a 25-year flood event and prevent facility damage or facility flooding during a 100-year flood event. During the 100-year flood event, facilities must be capable of passing the peak hydraulic flow as previously discussed.

All motor control centers (MCCs) and critical electrical components must be located above the 100-year flood elevation, and access to the plant must be maintained during flood events. For conditions greater than the 25-year flood event, the detailed design should minimize down-time to the maximum extent possible (i.e. long-term outages caused by flood events should be avoided).

Appendix

TREATMENT UNIT TABLE

TREATMENT UNIT	DIMENSIONS (SURFACE) LENGTH	DIMENSIONS (SURFACE) WIDTH	WATER DEPTH (m)	SURFACE AREA (m^2)	VOLUME (m^3)
A-1	77	37	4	2,849	6,570
A-2	77	37	4	2,849	6,570
F-11	96	37	2.5	3,552	5,500
F-12	96	37	2	3,552	4,360
F-13	93	37	1.75	3,552	3,814
F-21	96	37	2.5	3,552	5,500
F-22	96	37	2	3,552	4,360
F-23	96	37	1.75	3,552	3,814
M-11	74	37	1.5	2,800	2,470
M-12	74	37	1.5	2,800	2,470
M-21	74	37	1.5	2,800	2,470
M-22	74	37	1.5	2,800	2,470



LEGEND

EXISTING STRUCTURES

TRAIN 1

A-1 ANAEROBIC POND
F-11 FACULTATIVE POND
F-12 FACULTATIVE POND
F-13 FACULTATIVE POND
M-11 MATURATION POND
M-12 MATURATION POND

TRAIN 2

A-2 ANAEROBIC POND
F-21 FACULTATIVE POND
F-22 FACULTATIVE POND
F-23 FACULTATIVE POND
M-21 MATURATION POND
M-22 MATURATION POND

COMMON

DB DISINFECTION BASIN
PS PUMPING STATION
S SCREENING
M FLOW PARTITIONING

SCALE: 1:5000

Stearns & Wheler, PLLC
Environmental Engineers and Scientists
RALEIGH, NORTH CAROLINA

DATE: NOV 2005 JOB No.: 40295

THE HASHEMITE KINGDOM OF JORDAN
WATER AUTHORITY OF JORDAN

IRG/ECODIT AND USAID/JORDAN

UPGRADING OF THE MAFRAQ WASTEWATER TREATMENT PLANT

FIGURE 1
EXISTING FACILITIES

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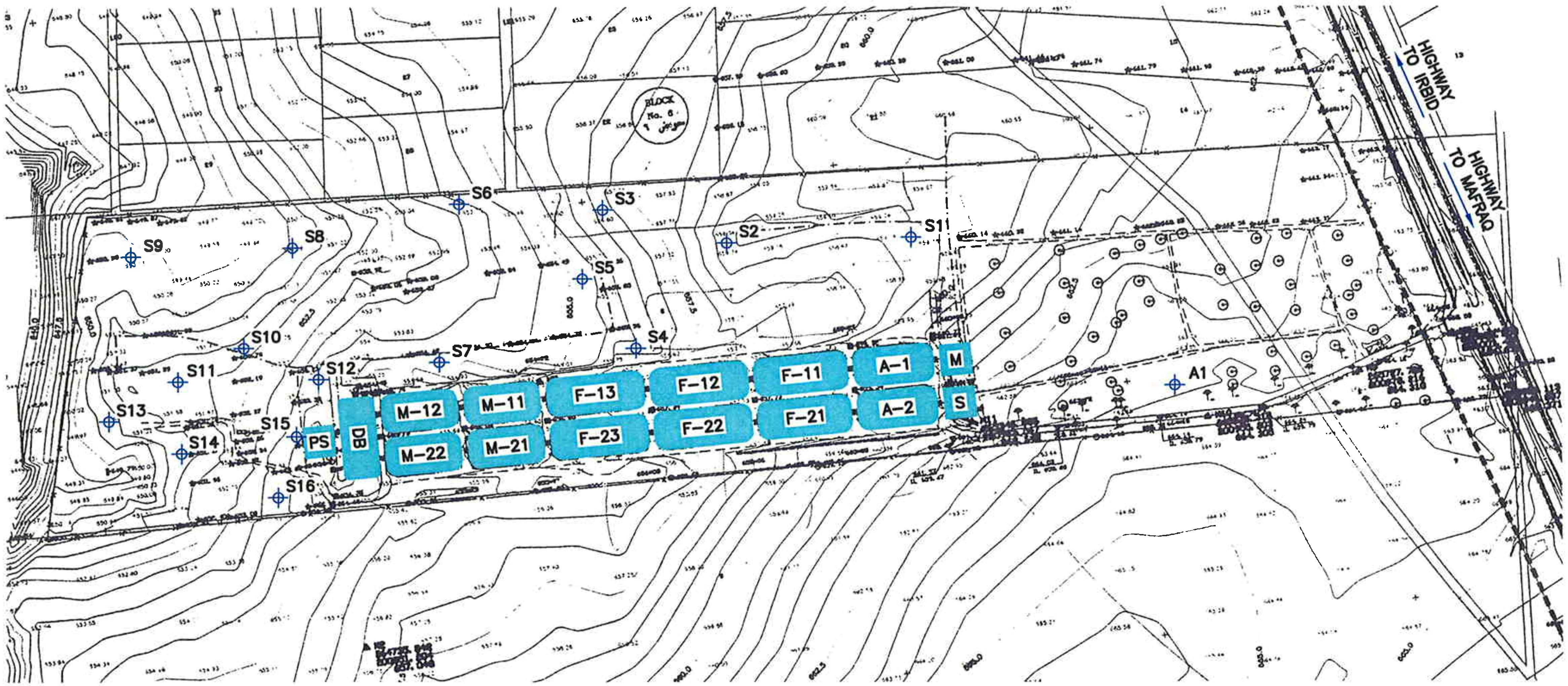
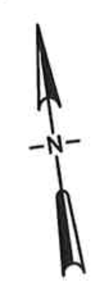
BORE HOLES IDENTIFICATION																	
DESCRIPTION	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	A1
BORE HOLE ELEVATION (m)	659.30	659.15	656.80	656.10	655.00	654.00	650.70	650.50	650.20	651.75	651.70	654.00	651.70	651.80	654.00	653.10	660.10
ROCK ELEVATION (m)	653.30	654.15	651.80	652.10	652.50	652.00	647.70	643.00	645.00	646.75	646.20	649.50	646.70	647.80	649.00	649.10	654.10
ROCK DEPTH (m)	6.00	5.00	5.00	4.00	2.50	2.00	3.00	6.50	4.80	5.00	5.50	4.50	5.00	4.00	5.00	4.00	6.00





LEGEND

EXISTING STRUCTURES

TRAIN 1

- A-1 ANAEROBIC POND
- F-11 FACULTATIVE POND
- F-12 FACULTATIVE POND
- F-13 FACULTATIVE POND
- M-11 MATURATION POND
- M-12 MATURATION POND

TRAIN 2

- A-2 ANAEROBIC POND
- F-21 FACULTATIVE POND
- F-22 FACULTATIVE POND
- F-23 FACULTATIVE POND
- M-21 MATURATION POND
- M-22 MATURATION POND

COMMON

- DB DISINFECTION BASIN
- PS PUMPING STATION
- S SCREENING
- M FLOW PARTITIONING

LEGEND

1. SOIL EXPLORATION DATA FROM NEC 2003 STUDY.
2. ADDITIONAL SOIL EXPLORATION IS RECOMMENDED BEFORE THE DETAILED ENGINEERING.

SCALE: 1:5000

Stearns & Wheler, PLLC
Environmental Engineers and Scientists
RALEIGH, NORTH CAROLINA

DATE: NOV 2005 JOB No.: 40295

THE HASHEMITE KINGDOM OF JORDAN
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UPGRADING OF THE MAFRAQ WASTEWATER TREATMENT PLANT

FIGURE 2
SOIL EXPLORATION RESULTS

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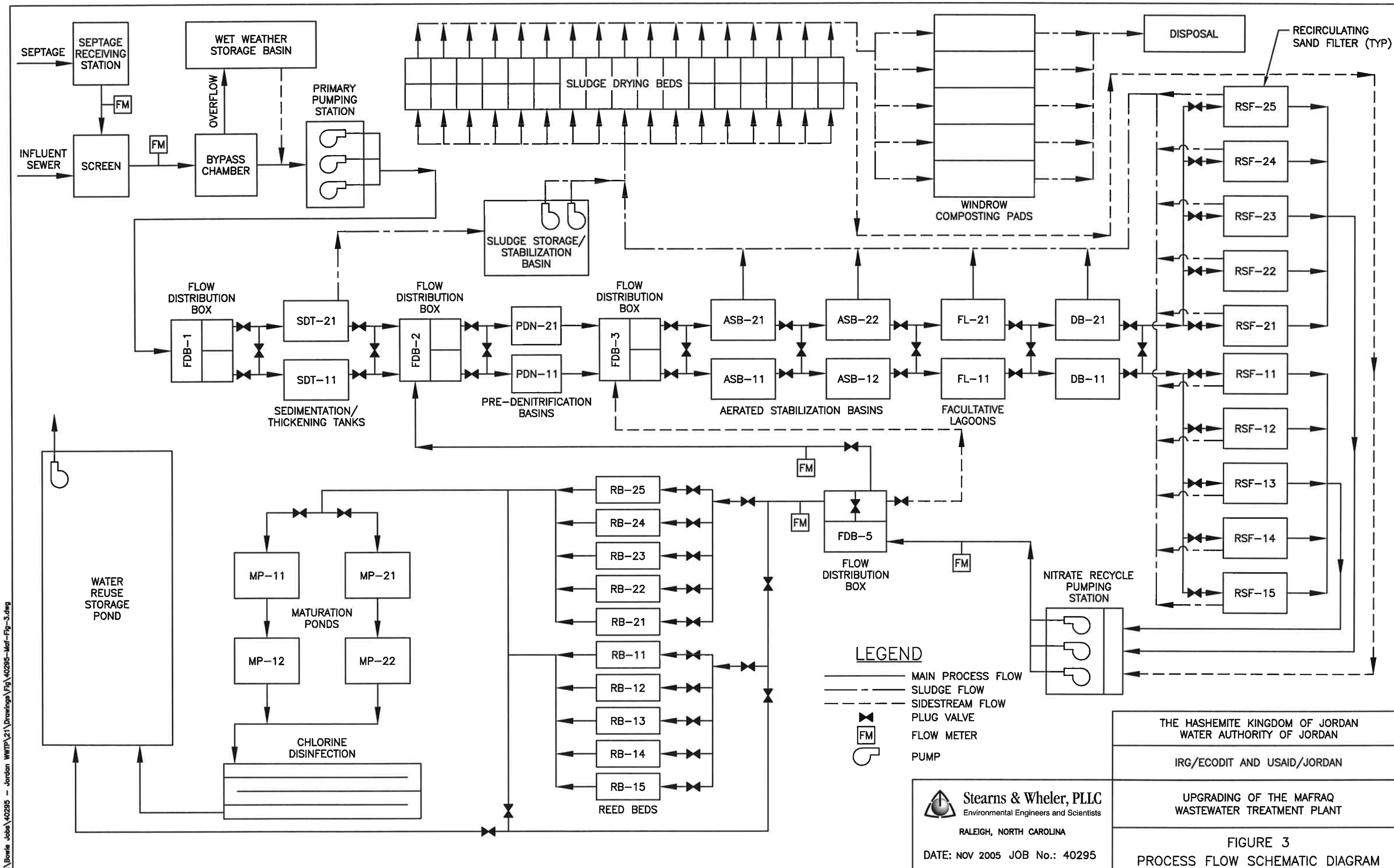

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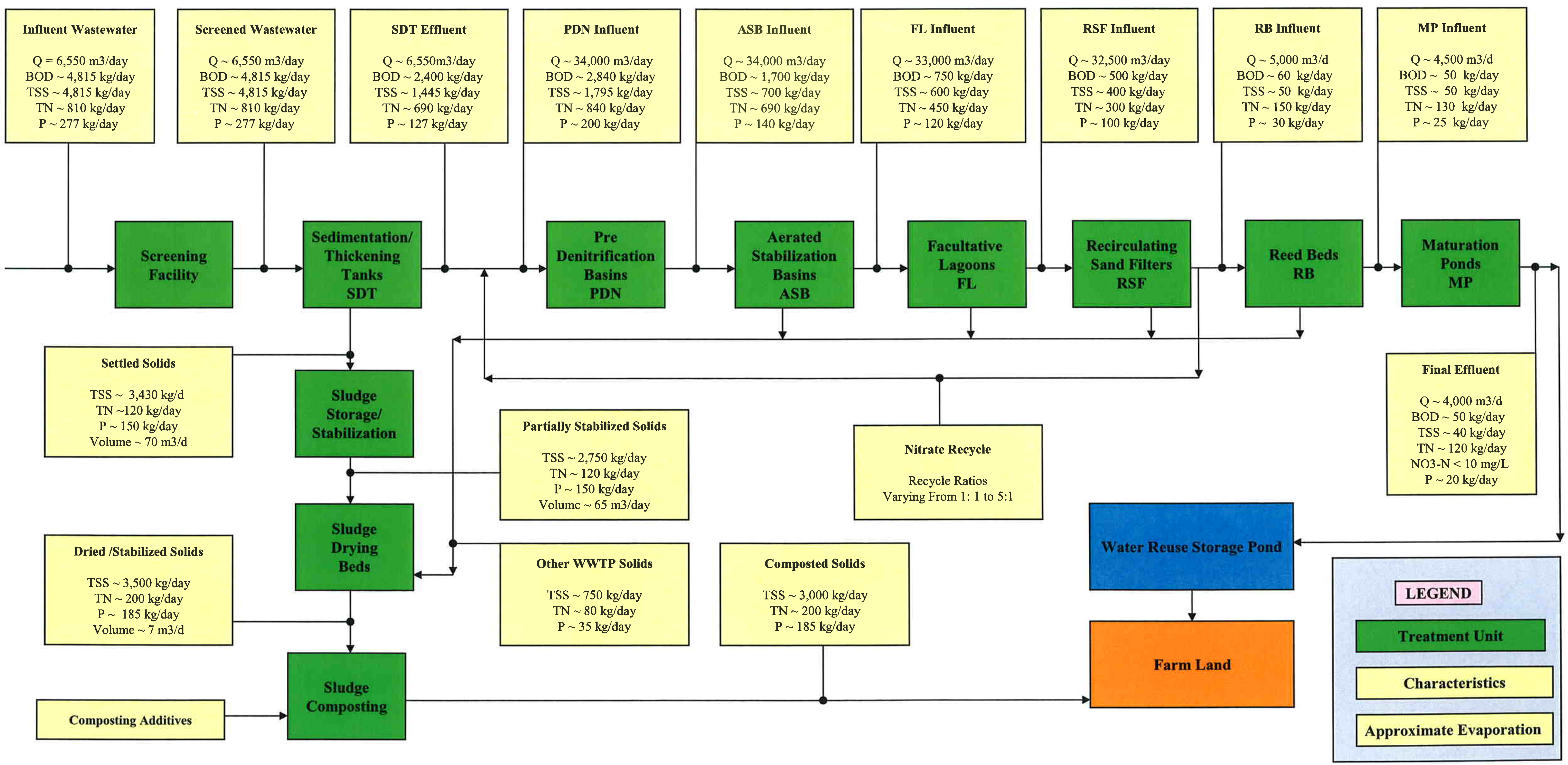
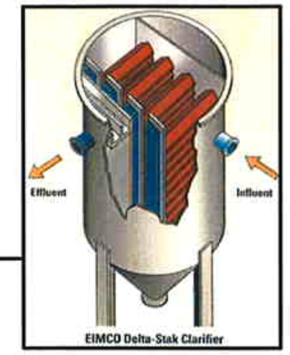
Figure 4
MAFRAQ WASTEWATER TREATMENT PLANT
Mass Balance Diagram
Maximum Design Conditions (2025)



STORAGE BASIN

CONSTRUCTED WETLANDS (REED BEDS)



SEDIMENTATION/THICKENING TANKS

PRE-DENITRIFICATION BASINS

SLUDGE DRYING BEDS

FACULTATIVE BASINS FILTER

MECHANICAL SCREENING

RECIRCULATING SAND FILTERS

AERATED STABILIZATION BASIN

LEGEND

(cyan)	EXISTING STRUCTURES
(green)	MODIFIED STRUCTURES
(red)	PROPOSED STRUCTURES
SMB	SERVICE & MAINTENANCE BUILDING
SSR	SCREENING FACILITIES
SRS	SEPTAGE RECEIVING STATION
PSP	PRIMARY PUMPING STATION
SDT-11 & SDT-21	SEDIMENTATION/THICKENING TANKS
PDN-11 & PDN-21	PRE-DENITRIFICATION BASINS
ASB-11 & ASB-21	AERATED STABILIZATION BASINS
ASB-12 & ASB-22	AERATED STABILIZATION BASINS
FL-11 & FL-21	FACULTATIVE LAGOONS
M-11, 12, 21 & 22	MATURATION PONDS
DB-11 & DB-21	DOSING BASINS
RSF	RECIRCULATING SAND FILTERS
RRPS	NITRATE RECYCLE/PUMPING STATION
CW (RB)	CONSTRUCTED WETLANDS (REED BEDS)
SDB	SLUDGE DRYING BEDS
DCB	DISINFECTION CONTACT BASIN
ES	EXISTING PRETREATMENT
SL	SLUDGE STORAGE LAGOON(S)
WCP	WINDROW COMPOSTING PADS
WWS	WET WEATHER STORAGE BASIN
WRSP	WATER REUSE STORAGE POND

N

SCALE: 1:5000

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WATER AUTHORITY OF JORDAN

IRG/ECODIT AND USAID/JORDAN

UPGRADING OF THE MAFRAQ
WASTEWATER TREATMENT PLANT

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FIGURE 5 – PROPOSED WASTEWATER TREATMENT FACILITIES

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LEGEND

(blue)	EXISTING STRUCTURES
(green)	MODIFIED STRUCTURES
(red)	PROPOSED STRUCTURES
(yellow)	FUTURE EXPANSION (BEYOND 2025)
SMB	SERVICE & MAINTENANCE BUILDING
SSR	SCREENING FACILITIES
SRS	SEPTAGE RECEIVING STATION
PSP	PRIMARY PUMPING STATION
SDT-11 & SDT-21	SEDIMENTATION/THICKENING TANKS
PDN-11 & PDN-21	PRE-DENITRIFICATION BASINS
ASB-11 & ASB-21	AERATED STABILIZATION BASINS
ASB-12 & ASB-22	AERATED STABILIZATION BASINS
FL-11 & FL-21	FACULTATIVE LAGOONS
M-11, 12, 21 & 22	MATURATION PONDS
CL-11, 12, 21 & 22	SECONDARY CLARIFIERS
DB-11 & DB-21	DOSING BASINS
RSF	RECIRCULATING SAND FILTERS
RRPS	NITRATE RECYCLE/PUMPING STATION
CW (RB)	CONSTRUCTED WETLANDS (REED BEDS)
SDB	SLUDGE DRYING BEDS
DCB	DISINFECTION CONTACT BASIN
ES	EXISTING PRETREATMENT
SL	SLUDGE STORAGE LAGOON(S)
WCP	WINDROW COMPOSTING PADS
WWS	WET WEATHER STORAGE BASIN
WRSP	WATER REUSE STORAGE POND

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FIGURE 6
FUTURE EXPANSION

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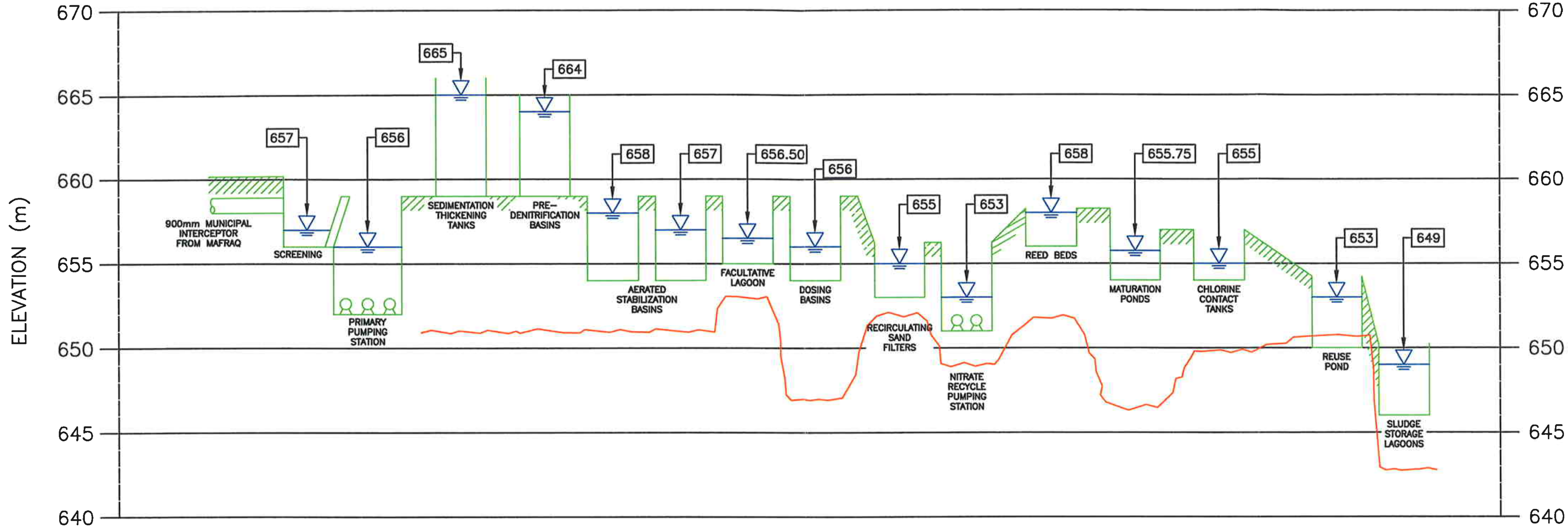

LEGEND

APPROXIMATE ROCK PROFILE BASED ON 2003 NEC STUDY

653 WATER ELEVATION AT PEAK FLOW OF 13,100 m^3/DAY

NOTES

1. THE HYDRAULIC PROFILE SHOULD BE UPDATED DURING DETAILED DESIGN BASED UPON MORE DETAILED GEOTECHNICAL INFORMATION.

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UPGRADING OF THE MAFRAQ WASTEWATER TREATMENT PLANT

FIGURE 7
HYDRAULIC PROFILE

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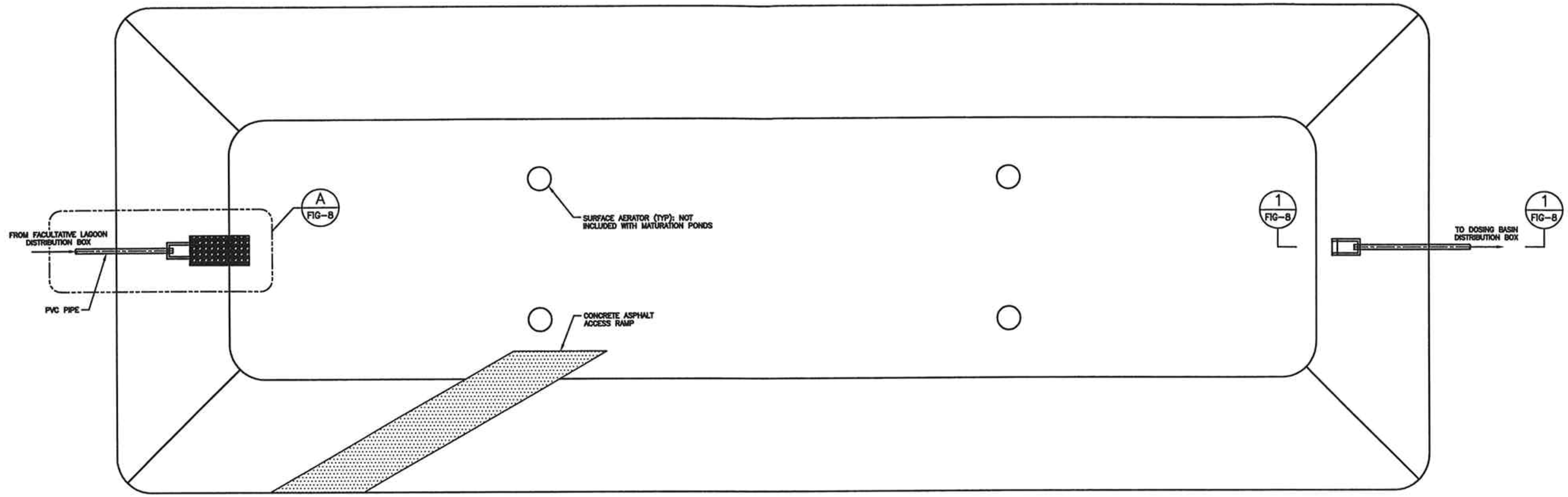
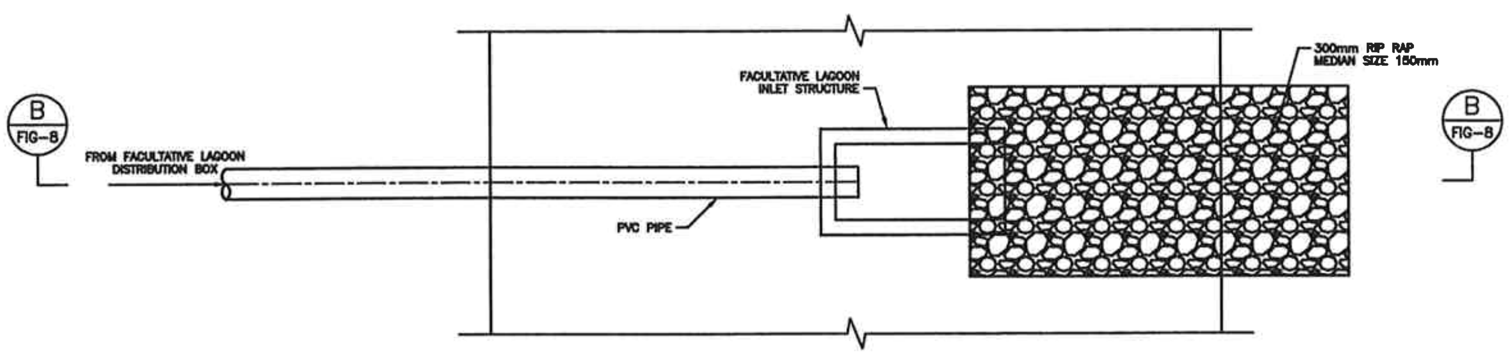
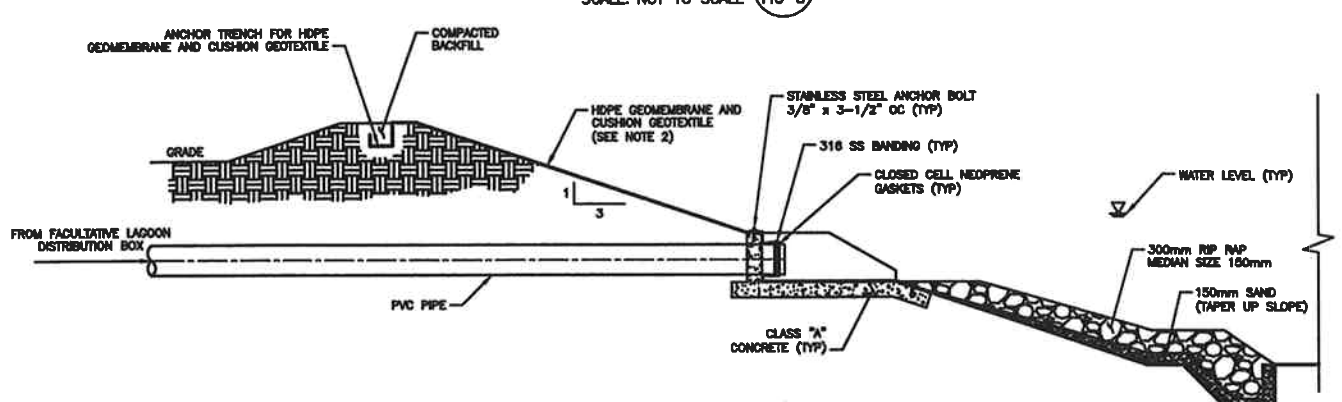


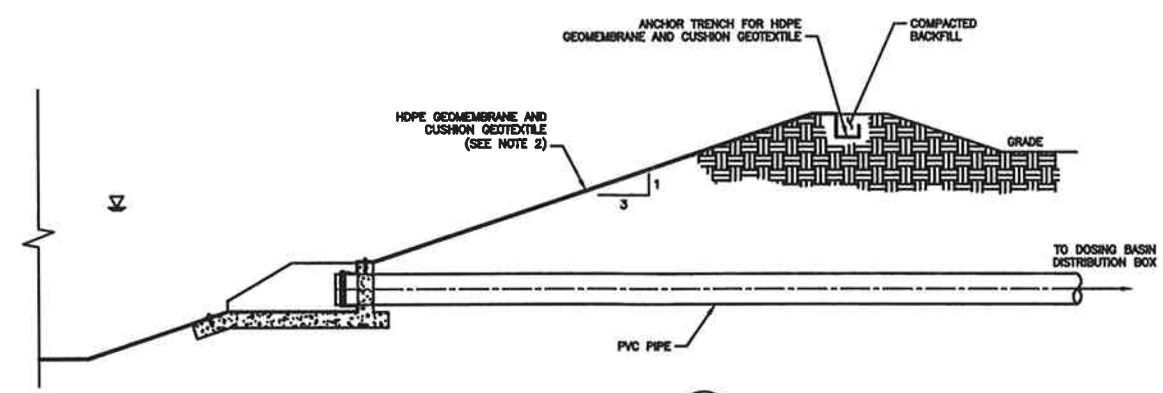
PLAN
NOT TO SCALE



DETAIL A FIG-8
SCALE: NOT TO SCALE



SECTION B FIG-8
SCALE: NOT TO SCALE



SECTION 1 FIG-8
SCALE: NOT TO SCALE

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Stearns & Wheler, PLLC Environmental Engineers and Scientists RALEIGH, NORTH CAROLINA	UPGRADING OF THE MAFRAQ WASTEWATER TREATMENT PLANT
DATE: OCT 2005 JOB No.: 40295	FIGURE 8 – TYPICAL AERATED STABILIZATION BASIN AND MATURATION POND

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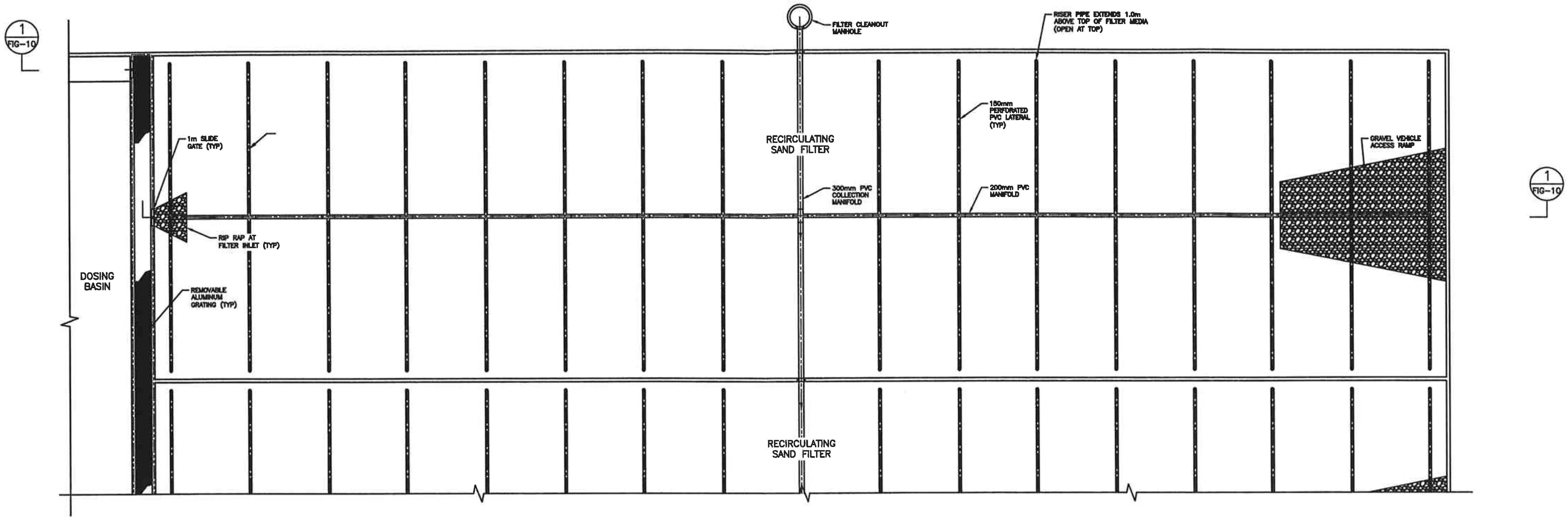
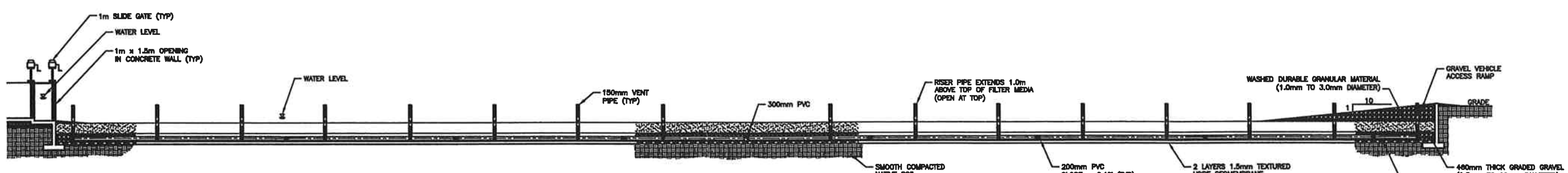


RECIRCULATING SAND FILTER – PLAN
NOT TO SCALE



SECTION 1 FIG-10
SCALE: NOT TO SCALE

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FIGURE 9
TYPICAL RECIRCULATING SAND FILTER

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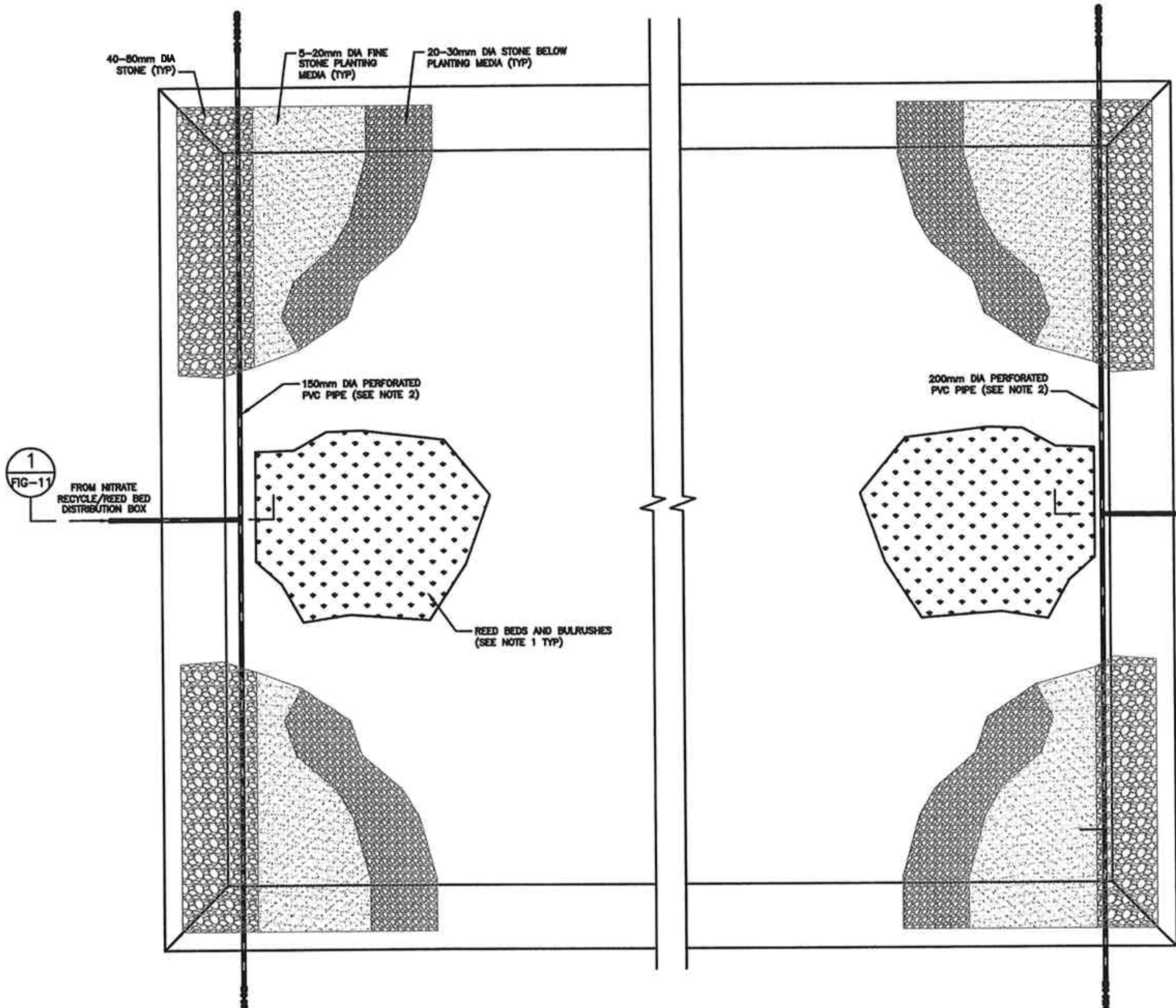
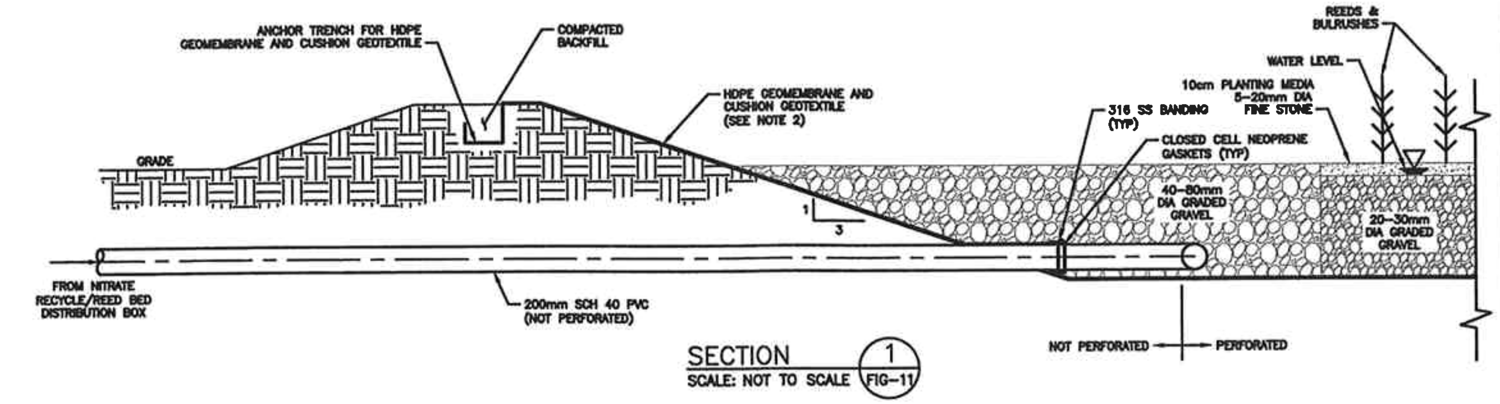
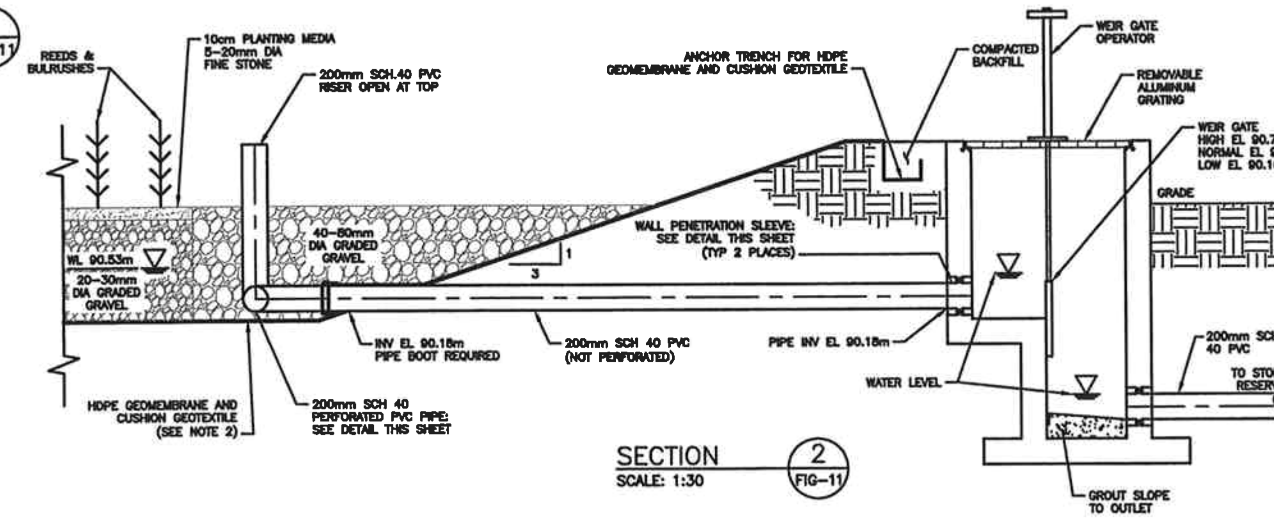


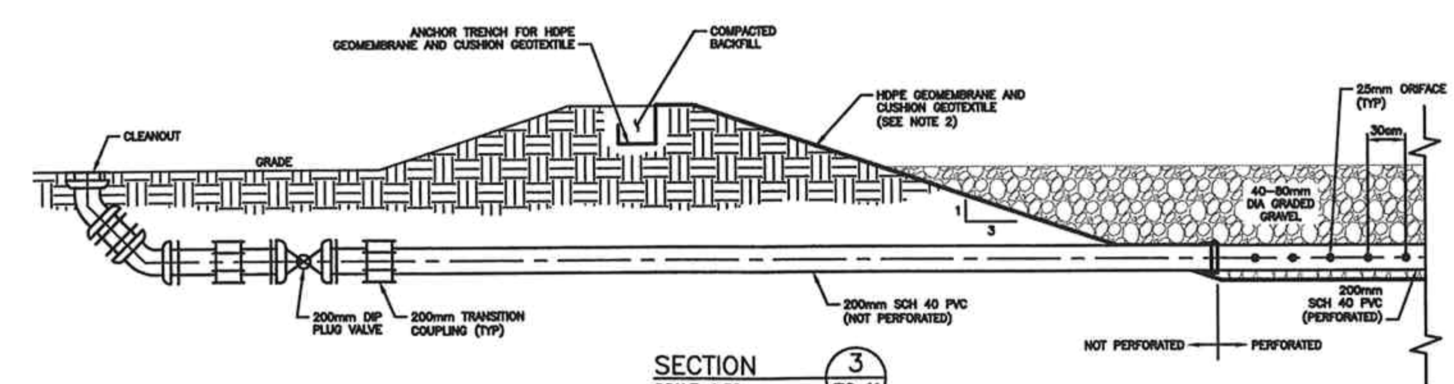
REED BED – PLAN
SCALE: 1:200



SECTION 1 FIG-11
SCALE: NOT TO SCALE



SECTION 2 FIG-11
SCALE: 1:30



SECTION 3 FIG-11
SCALE: 1:30

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UPGRADING OF THE MAFRAQ WASTEWATER TREATMENT PLANT

FIGURE 10
TYPICAL REED BED

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